ARIZONA DEPARTMENT OF TRANSPORTATION

GENERAL SPECIFICATIONS FOR PHOTOGRAMMETRIC MAPPING

Revised 2009

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SECTION #

Arizona Department of Transportation
Engineering Survey Section
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SECTION 1 - GENERAL

1-1.00 Intent of Specifications, Special Provisions, and Plans

1-1.01 The intent of the specifications, special provisions, and plans is to prescribe the details for performance and completion of the work which the Consultant undertakes in accordance with the terms of the Contract where the specifications, special provisions, and plans describe portions of the work in general terms but not in complete detail. It is understood that only the best general practice is to prevail and that only materials and workmanship of the first quality are to be used. Unless otherwise specified, the Consultant will furnish all labor, materials, tools, equipment, incidentals, and produce all the work involved in executing the Contract.

1-1.02 The work to be done consists of creating Digital Terrain Models (DTM's) using photogrammetric methods supplemented with spot elevations at a specified scale as described in the special provisions. The work to be done may require the Consultant to furnish the topographic field control data and materials necessary for creating the topographic maps.

1-1.03 The work will be shown on a set of plans included as part of the special provisions. The location and identification of the project will also be shown.

1-1.04 Unless otherwise specified in the special provisions, the Consultant will furnish:

1. CD's or DVD's in the specified format which can be loaded into ADOT's CADD system (see Section 5 for map file requirements). The disk sleeve will be labeled with the project number and file names found on the enclosed disk. Files subjected to compression schemes such as zip, tar, gz, etc., are not acceptable.

SECTION 2 - DELIVERY SCHEDULE

2-1.00 Refer to special provisions for time of completion, material to be delivered, and delivery address.

SECTION 3 - FIELD CONTROL

3-1.00 General

3-1.01 If the Consultant is required to furnish the field control data, it will be provided in accordance with ADOT Specifications entitled *Specifications for Topographic Map Control Surveys*, and in accordance with the special provisions of the Contract.

SECTION 4 - AERIAL PHOTOGRAPHY

4-1.00 General

4-1.01 The aerial photography will be provided in accordance with ADOT *General Specifications for Aerial Photography* (dated 2008), and in conformance with the special provisions of the Contract.

4-1.02 The Consultant will furnish all aerial photographs, diapositives and/or scanned image files. Scanned images will be scanned at 14 micron resolution, 8 bits/pixel, untiled, uncompressed tiff format.

4-1.03 The aerial photography scale will be stated in the special provisions.

An aerial photography index will be furnished by the Consultant.

4-1.04 The Consultant's aerial camera and current calibration report is to be in accordance with ADOT *General Specifications for Aerial Photography* (dated 2008). The type of aerial camera to be used and the calibration report will be submitted to ADOT for approval before award of the Contract.

SECTION 5 - DTM AND PLANIMETRIC MAPS

5-1.00 Stereoscopic Softcopy Workstations

5-1.01 The work will be planned for a softcopy photogrammetric workstation.

5-1.02 The aerial photo and map (compilation) scales to be used by the Consultant will be submitted to ADOT for approval before award of the Contract.

5-2.00 General

5-2.01 The North American Datum of 1983/1992 (NAD 83/92) will be used for horizontal control; the North American Vertical Datum of 1988 (NAVD 88) will be used for vertical control. International feet will be used for all mapping projects except when matching or extending existing mapping based on North American Datum of 1927 (NAD 27). Unless otherwise specified, all mapping will be placed on a ground datum utilizing the Arizona State Plane Coordinate System Grid Adjustment Factors (see ADOT *General Specification for Map Control Surveys*, Sec 2-1.11).

5-2.02 Final maps will show all grid ticks as well as horizontal and vertical control. It is the Consultant's responsibility to show the horizontal/vertical control data in conformance with the special provisions.

5-2.03 Maps will be compiled at the scale and contour interval specified in the special provisions.

5-2.04 The mapping limits, along with the numbering, dimensions, and orientation of the final maps, will be as shown on the plans.

5-2.05 Adjacent map files will edge match exactly. Matching features will be snapped three-dimensionally between adjacent files. Overshoots and undershoots are not acceptable.

5-2.06 The Consultant will select an appropriate symbol and label the feature as unidentified when the symbols shown do not accurately describe a planimetric feature.

5-2.07 Labels will be oriented along linear features or parallel to the flight line of the stereo model. The project's beginning will be to the left and project's end will be to the right.

5-3.00 Guidelines for Digital Photogrammetric Stereocompilation

5-3.01 ADOT Photogrammetry & Mapping (ADOT P&M) Section uses Cardinal System's VR Photogrammetry suite for internal production of mapping products. These files are then translated into the most current version of Bentley MicroStation format for editing and delivery to the end-user. To ensure the Consultant's maps are compatible with the ADOT CADD System, the following requirements must be met:

a) **Maps produced on a CADD system by the Consultant will conform to ADOT's current CADD Standards. This includes levels, line codes, line weights, line color, symbols, and text.**

b) The Consultant's photogrammetric CADD software must be capable of importing or directly reading the orientation files provided by ADOT P&M Section. Typical measurement file types are ISAT, PATB, ALBANY, and VRAT.

c) The data files provided by the Consultant will be in the most current version of Bentley MicroStation vector file format. If the Consultant uses the current Cardinal System VR suite, they must install and use the function keys and symbol libraries provided by the ADOT P&M Section. Failure to do so may result in rejection of submitted data. Raster image files and file formats such as DXF, DWG, or SIF are not acceptable.

d) All files provided by the Consultant will be delivered on either CD or DVD, depending on project file sizes. CD's will be recorded as type "Mode 1" and conform to the "ISO+Joliet" file system standard. DVD's will conform to the "ISO+Joliet+UDF" file system standard.

e) Prior to delivery, the Consultant will scan the deliverable media for the presence of viruses or other malicious code. Failure to do so may result in rejection of submitted media.

f) The use of reference files or pen tables to achieve particular plotted effects is not allowed; each file must stand on its own.

g) Each file will contain map features corresponding to one stereo model only. The delivered data will be cleanly edited and will not contain crossing breaklines or mismatched elevations at edge-matched vertices.

h) Each file will contain all 3D terrain and planimetric features. Use of planimetric levels for DTM triangulation is permissible (e.g. edge of pavement, centerline stripes, drainage lines, etc). ADOT P&M Section will provide the Consultant with a list of planimetric levels used for of DTM triangulation. (See Appendix A).

i) Planimetric features used for DTM triangulation will not contain complex lines or shapes which cannot be triangulated. Use of arcs is permissible if these line types are "stroked" or "exploded" in such a way that the DTM engine can successfully triangulate that feature.

j) Files will be compiled with coordinate values to the nearest thousandth (1/1000) of a foot. Coordinate values for all features will be based on the grid system indicated by the control data. MicroStation design file working will be:

k) Master Units = 1 Ft: Sub Units = 10 (1/10 Ft.): Positional Units = 100 (1/1000 Ft.)

l) The global origin will be set such that the working units' origin (0.0) will be at the center of the design plane. See ADOT "CADD Standards" manual for more information. The current standard ADOT MicroStation seed file (seed3d.dgn), may be obtained from the ADOT website or will be provided to the Consultant upon request. CADD resources may be obtained directly from ADOT CADD Management & Support.

m) All digital data will be measured directly as a function of the softcopy operation. Auto-correlated points or interpolated line strings are not allowed. Post-compilation digitizing of features is not permitted. Use of manually collected mass points for DTM generation is permitted, however these points may not be used to derive spot elevations. All spot elevations will be observed and measured manually. Spot elevations will conform to the specifications set forth in section 5, paragraph 6.10 through 6.16 and section 5, paragraph 8.20 of this document.

n) Each data file will have an exterior boundary breakline along the outside edge of the mapping limits. The breakline will be manually digitized and will follow the terrain three-dimensionally (auto-correlated or draped 2D lines are not allowed). The exterior boundary will be digitized no more than 5' outside the mapping limits.

5-4.00 Contents of Maps

5-4.01 All map features will be collected in accordance with the ADOT *CADD Standards Manual*, available from ADOT Engineering Records Services.

5-5.00 Monuments, Bench Marks and Grid System

5-5.01 Grids will be shown as one inch long cross-ticks spaced at ten inch intervals at final map scale. Grid ticks will be labeled along the perimeter of the map. Grid ticks on adjacent maps will be a continuation of the ten inch interval. In addition to this requirement, adjoining maps will have a least two grid ticks in common to both maps. Intermediate grid tick intervals will be used when necessary to fulfill this requirement; intermediate grid ticks need not be labeled.

5-5.02 Grid coordinate values will be designated X and Y.

5-6.00 Topographic Features

5-6.01 Spot elevations will be shown at intervals not greater than 2 inches at final map scale when the profile grading is 2 percent or less. Spot elevations will be shown at all sags and crests regardless of gradient. Additionally, spot elevations will be shown along the center of dikes, roads, ditches, and railroads.

5-6.02 Spot elevations will be shown at intervals not exceeding 2 inches at final map scale, along the boundary of the area to be mapped at locations where the nearest contour is over 1 inch from the boundary.

5-6.03 Spot elevations will be shown where contour interpolation will not show correct elevations (e.g. summits, depressions, saddles, road intersections, etc.).

5-6.04 Spot elevations will be labeled with decimal values giving their elevation to three significant figures, rounded to the nearest one-tenth of a foot (i.e. an elevation text label of 2574.136' will be shown as 74.1). Labels will be placed parallel with the flight line and positioned so that they do not obscure other map features. The spot elevation text will be offset from the spot symbol so as to not obscure the spot symbol.

5-7.00 Planimetric Features – Design Level Mapping (1" = 50')

5-7.01 Planimetric features visible, identifiable on, or interpretable from the aerial photography will be shown. Particular attention will be given to all roadway features, utility and drainage features, fences, walls, and other indications of property lines or lines of occupation.

Maps will show all roads, railroads, bridges, canals, streams, dams, walls, fence lines, wells, power and telephone poles, signage and billboards visible on the aerial photographs. They will also show boundaries of timber and brush areas, slide and slip out areas, orchards, vineyards, and any other visible improvements or distinguishing features.

Symbols such as signs, mast lights, guy wires, etc., will be properly rotated to reflect the object's actual orientation.

The use of shared cells is not acceptable.

Orchards planted in regular rows may be symbolized by a dot for each tree, except for the outer rows which will be shown by appropriate symbol. Free standing trees having a crown diameter of 15 feet or more will be shown.

Saguaro cacti will be shown using the appropriate symbol.

Schools, parks, playgrounds, cemeteries, public buildings, hospitals, churches, institutions, and similar places of public gatherings will be shown.

Roadway lane striping will be delineated by the appropriate line style. Centerlines, fog stripes, gore point striping, and crosswalk lines will be shown. Collection of turn arrows and handicapped parking symbols painted on asphalt surfaces is not required.

ADOT P&M Section will furnish the Consultant with digital files containing 3D points corresponding to field collected structures such as tops of pipes, inverts, flow points, culverts, catch basins, headwalls, wingwalls, edge of pavement, centerlines, right of way markers, mileposts, bridge decks and approaches, etc.. The Consultant will reference the supplied point files when collecting these features and will snap the appropriate symbol origin or line vertex to these furnished points.

Should a vertical or horizontal discrepancy exist between a field collected point and the photogrammetric measurement which exceeds standards, the Consultant will advise ADOT P&M Section of the discrepancy along with the point name and the amount of the error measured.

Should the Consultant find omitted features not collected in the field, the Consultant will measure and collect the feature and make a note of the coordinate of the missing feature. ADOT P&M Section will be notified by the Consultant of these missing features and supply ADOT P&M Section with the measured coordinate and feature type.

5-7.02 Roads, streets, and sidewalks will be shown as the separation between curb faces, hard surface edges, travel paths, or shoulder lines. The drafting of road alignment should be carefully executed. Roads of regular alignment will be plotted with straightedge and regular curves. Freehand or irregular curve drawing will be permitted only on meandering roads, trails, or irregular alignments.

5-7.03 Linear patterns visible but not easily identifiable on the aerial photographs, will be located and shown on the map by fine dotted lines.

5-8.00 <u>Accuracy of Maps</u>

5-8.01 Map accuracies specified herein will apply to the individual stereo models which comprise the finished maps delivered by the Consultant.

5-8.02 The plotted position of all coordinate grid ticks, grid lines, and monuments (except bench marks) will not vary more than 0.01 inch from their calculated position.

5-8.03 At least 90 percent of all well-defined planimetric features will be within 0.025 inch of their true position; 100 percent of all well-defined planimetric features will be within 0.050 inch of their true position.

The width of all curbed streets, vehicular structures, traffic lanes, and highway surfaces, whose edges are well-defined, will not vary more than 0.025 inches from their true width. The street side of lines delineating curbs will be the face of the curb.

5-8.04 At least 90 percent of all contours will be within one-half contour interval of true elevation; all contours will be within one contour interval of their true elevation, except as follows:

a) **In densely wooded areas where the ground is obscured by dense brush or tree cover, contours will be plotted as accurately as possible, while making maximum use of spot elevations obtained from the stereoscopic model in places where the ground is visible and/or with elevations furnished by field survey methods.**

b) **In those areas where spot elevations can be obtained photogrammetrically and/or if elevations are furnished by field survey methods, at least 90 percent of all contours will be within one contour interval or one-half the average height of the ground cover, whichever is the greater, of true elevation. All contours will be within two contour intervals or the average height of the ground cover, whichever is the greater, of true elevation.**

c) **Orchards, vineyards, and areas devoted to crops will be considered as open areas and are therefore not subject to larger tolerances in vertical accuracy.**

5-8.05 The accuracy tolerance allowed for contours will not affect the requirement that contours reflect the crown or cross slope of all paved areas including paved ditches.

5-8.06 In areas not obscured by grass or brush, at least 90 percent of all spot elevations will be within 0.25 contour interval of their true elevation and 100 percent will be within 0.50 contour interval of their true elevation. In addition to the accuracy specified above for contours and spot elevations, the following will apply:

The arithmetic mean of contours and spot elevations in open areas will not exceed plus or minus the following values for the points tested on each map sheet.

No. of Points Tested	Max. Arithmetic Mean
20	+/- 0.20 C.I.
40	+/- 0.15 C.I.
60	+/- 0.10 C.I.

5-8.07 If discrepancies occur between information furnished by the Contracting Engineer and information obtained by the Consultant, the Consultant will immediately notify the Engineer. The Engineer will investigate and advise the Consultant in writing on how to resolve the discrepancy. The instructions issued by the Contracting Engineer will be final and conclusive.

6-6.00 Orthophotographs and Mosaics

6-6.01 The Consultant will have the capability to produce Orthophotographs at the same accuracy as the DTM or provided relative to the photograph scale used for the original DTM. If bridge decks or similar features are present, the DTM will be modified to properly rectify them. Rectified bridge decks should appear natural not distorted.

6-6.02 ADOT will accept tiff & tfw, geotiff, or sid & sdw file formats. If a sid & sdw file format is submitted, the original tiff & tfw or geotiff image files must be also provided.

6-6.03 Black and white image data will be represented as 8-bit binary data; color image data will be represented as 24-bit binary data.

6-6.04 Images will be re-sampled/transformed using the bilinear interpolation method. The cubic convolution method will also be accepted but is not required. Orthophotographs re-sampled using the nearest neighbor method will not be accepted.

6-6.05 Orthophotographs will be rectified using the Arizona State Plane Coordinate System, NAD 83/92, NAVD88, and international foot.

6-6.06 Orthophotographs will have the uppermost left-hand pixel designated as (0, 0) and have a pixel rotation of 0 degrees.

6-6.07 Orthophotographs will be submitted with an over-edge/background color of 255 (white). This facilitates plotting hardcopies for public displays.

6-6.08 Orthophotographs will be free of visual anomalies such as smears, fingerprints, lint, etc., which render the imagery visually unaesthetic at a zoom scale ratio of 1 to 1.

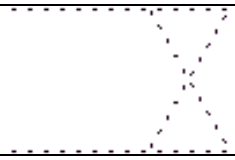
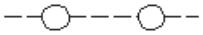
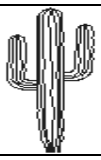
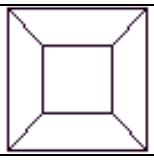
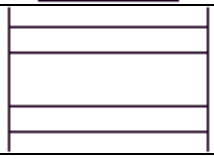
6-6.09 Orthophotographs will be compatible with the most current version of MicroStation and delivered on CD or DVD (file sizes will be limited to what can fit on a CD or DVD). Jewel case and CD labels will contain project name, ADOT Tracs number, route number, beginning and ending mile posts, and ADOT P&M Section job number.

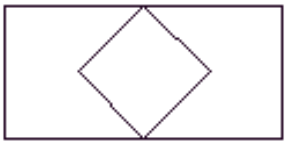
6-6.10 The pixel resolution/ground sample distance of orthophotographs will be produced in accordance with table 2-10 of the *US Army Corps of Engineers (USACE) Manual No. 1110-1-1000*, (dated 31 July, 2002) available from the World Wide Web.

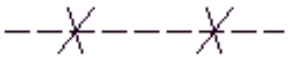
6-6.11 The Consultant will furnish orthophotograph metadata to ADOT P&M Section. The metadata may be a simple text file and will include: ADOT Tracs number, project name and description, route number, mile posting, number of delivered orthophotographs, number of CADD files, number of disks delivered, date of delivery, consultant company, project manager, contact information, coordinate system zone, NAD/NAVD data type, original photography date and scale, camera, film and file type, pixel resolution, compression type and ratio, and tile size (if applicable).

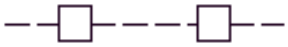
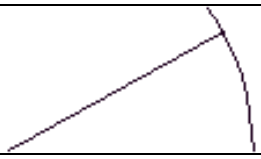
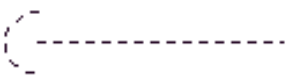
6-6.12 Note: DTM's or DEM's used for the creation of Orthophotographs may not be used for other purposes unless approved by ADOT P&M Section.

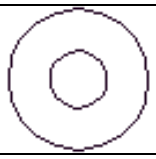
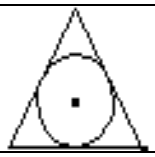
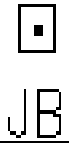
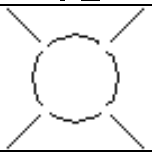
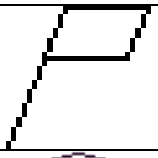
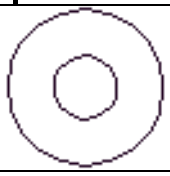
Appendix A
ADOT Photogrammetry Standard Symbology

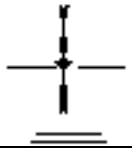
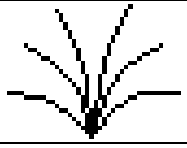
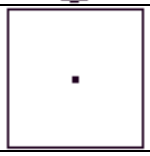
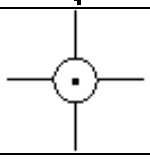
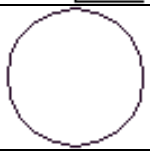
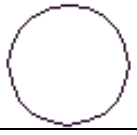
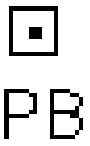
Micro-Station Level	Description	Symbology	Triangulated
13	Apron	Solid	No
16	Asphalt Road	Solid	**Yes**
13	Bank Protection		No
3	Breaklines	Solid	**Yes**
22	Bridge Deck	Line Code 5	No
22	Bridge Walkway	Solid	No
7	Brush Line		No
9	Building	Solid	No
9	Building Un-Squared	Solid	No
23	Cable Barrier		No
7	Cactus		No
9	Canopy	Solid	No
13	Catch Basin Curb		No
13	Catch Basin Med		No
13	Catch Basin Off Road		No
9	Cattle Guard		No

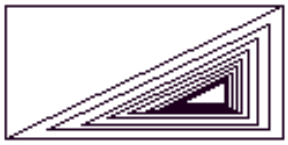
Micro-Station Level	Description	Symbology	Triangulated
17	Centerline 3D		**Yes**
17	Centerline Bridge		No
13	Concrete Drain	Line Code 5	No
16	Concrete Road	Line Code 5	No
9	Concrete Slab	Line Code 5	No
5	Contours Index	Solid	No
5	Contours Index Depression		No
6	Contours Intermediate	Solid	No
6	Contours Intermediate Depression		No
17	Control Box		No
13	Culvert		No
23	Curb	Solid	**Yes**
13	Dam		No
13	Dike Levee		No
16	Dirt Road		**Yes**

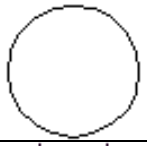
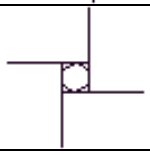
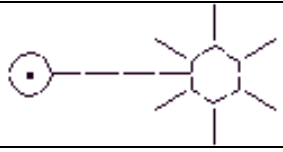
Micro-Station Level	Description	Symbology	Triangulated
16	Dirt Trail		**Yes**
13	Ditch Concrete		No
13	Ditch Earth		No
13	Down Drain		No
17	Driving Stripe		No
25	Exterior Boundary	Solid	**Yes**
29	Fence Barbwire Long		No
29	Fence Barbwire Short		No
29	Fence Chain-Link Long		No
29	Fence Chain-Link Short		No
29	Fence Wood Long		No

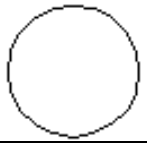
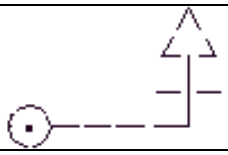
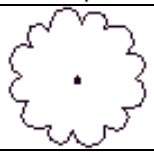
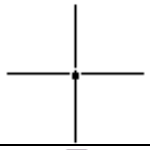
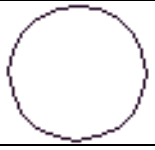
Micro-Station Level	Description	Symbology	Triangulated
29	Fence Wood Short		No
11	Fire Hydrant		No
9	Flag Pole		No
8	Flow Term		No
8	Flowline		**Yes**
29	Gate Double		No
29	Gate Single		No
29	Gate Sliding		No
23	Guardrail		No
23	Gutter	Solid	**Yes**
11	Guy Wire		No

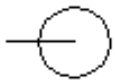
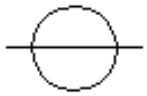
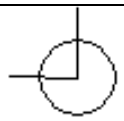
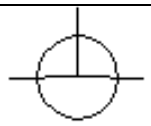
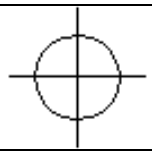
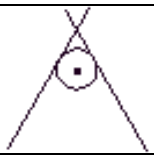
Micro-Station Level	Description	Symbology	Triangulated
13	Hand Hole		No
9	Handicap Ramp	Solid	No
9	Handrail	Solid	No
22	Headwall	Solid	No
2	HV Control		No
11	Junction Box		No
17	Light Pole		No
9	Mailbox Multiple		No
9	Mailbox Single		No
13	Manhole		No
1	Mapping Limits	Solid	No
25	Match Line	Solid	No
23	Median Barrier		No
11	Meter		No
9	Mine Prospect		No

Micro-Station Level	Description	Symbology	Triangulated
25	North Arrow		No
33	Obscured Area	Line Code 3	No
7	Ocotillo		No
9	Parking Meter		No
11	Pedestal		No
17	Pedestrian Light		No
2	Photo Centers		No
13	Pipe	Line Code 3	No
13	Pipe Capped		No
11	Pole		No
9	Pools	Solid	No
9	Post Misc		No
11	Pullbox		No

Micro-Station Level	Description	Symbology	Triangulated
55	Rock Outcrop		No
11	RR 100		No
11	RR 50		No
11	RR Cabinet		No
11	RR Gate		No
11	RR Switch		No
9	Ruins	Solid	No
9	Satellite Dish		No
9	Sidewalk Concrete	Line Code 5	**Yes**
9	Sidewalk Paved	Line Code 2	**Yes**
9	Sign Billboard		No
17	Sign Bridge		No
17	Sign Cantilever		No

Micro-Station Level	Description	Symbology	Triangulated
9	Sign Commercial		No
17	Sign Delineator		No
17	Sign DS1P		No
17	Sign DS2P		No
25	Sign Milepost		No
17	Sign SS1P		No
17	Sign SS2P		No
17	Sign Street		No
13	Spillway	Line Code 3	No
2	Spot Elevations		No
11	Standpipe		No
17	Streetlight Mast		No

Micro-Station Level	Description	Symbology	Triangulated
9	Tank Circular		No
9	Tank Gas		No
11	Telephone Booth		No
11	Tower Radio		No
11	Tower Trans		No
17	Traffic Signal		No
7	Tree Palm		No
7	Tree Scaled		No
7	Treeline		No
2	Unidentified Panels		No
33	Unknown Circular		No
33	Unknown Square	Solid	No

Micro-Station Level	Description	Symbology	Triangulated
11	Utility Pole 1T		No
11	Utility Pole 2T		No
11	Utility Pole 2T CR		No
11	Utility Pole 3T		No
11	Utility Pole 4T		No
11	Utility Pole Tick		No
11	Valve		No
29	Wall Block		No
22	Wall Bridge		No
22	Wall Retaining		No
11	Windmill		No
22	Wingwall	Solid	No

Appendix B
Sample Mapping Data

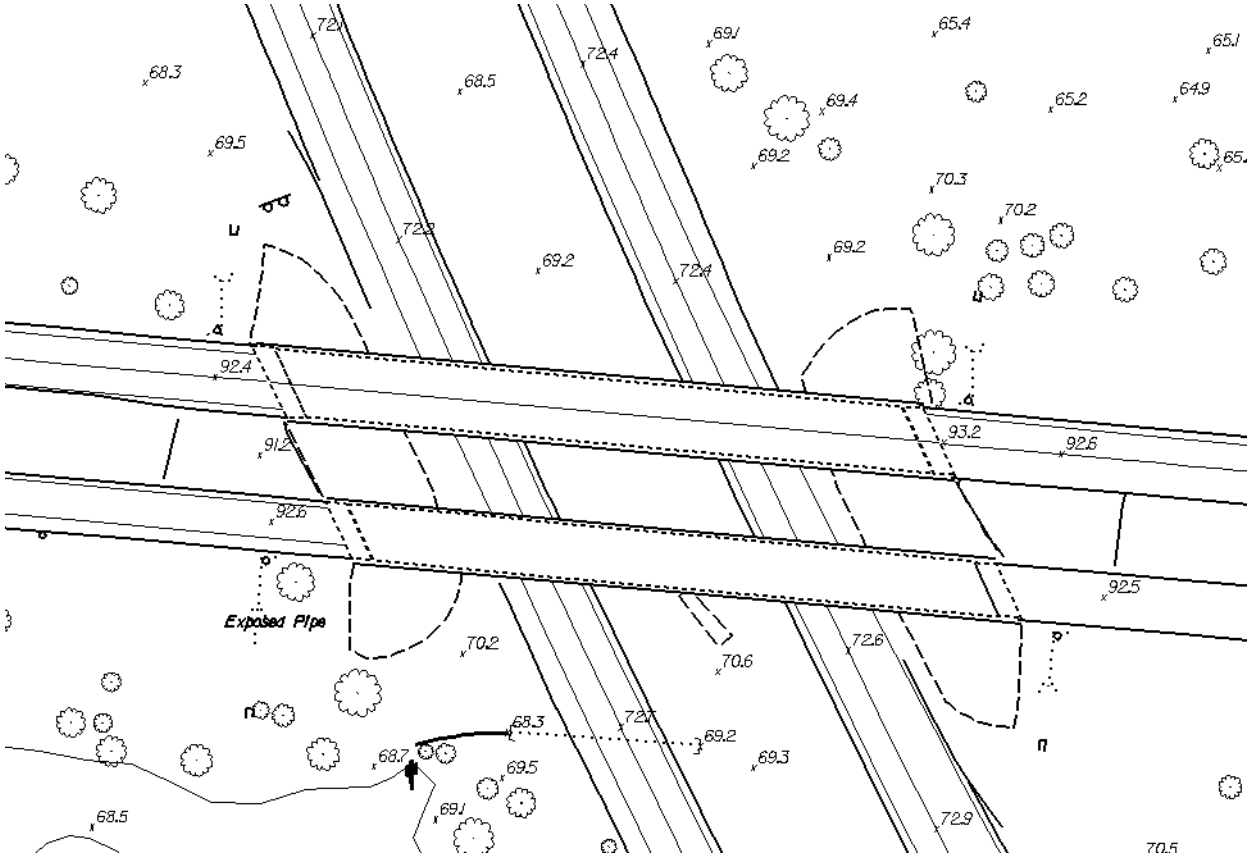


Figure 1 – Planimetric File Data

Appendix B
Sample Mapping Data

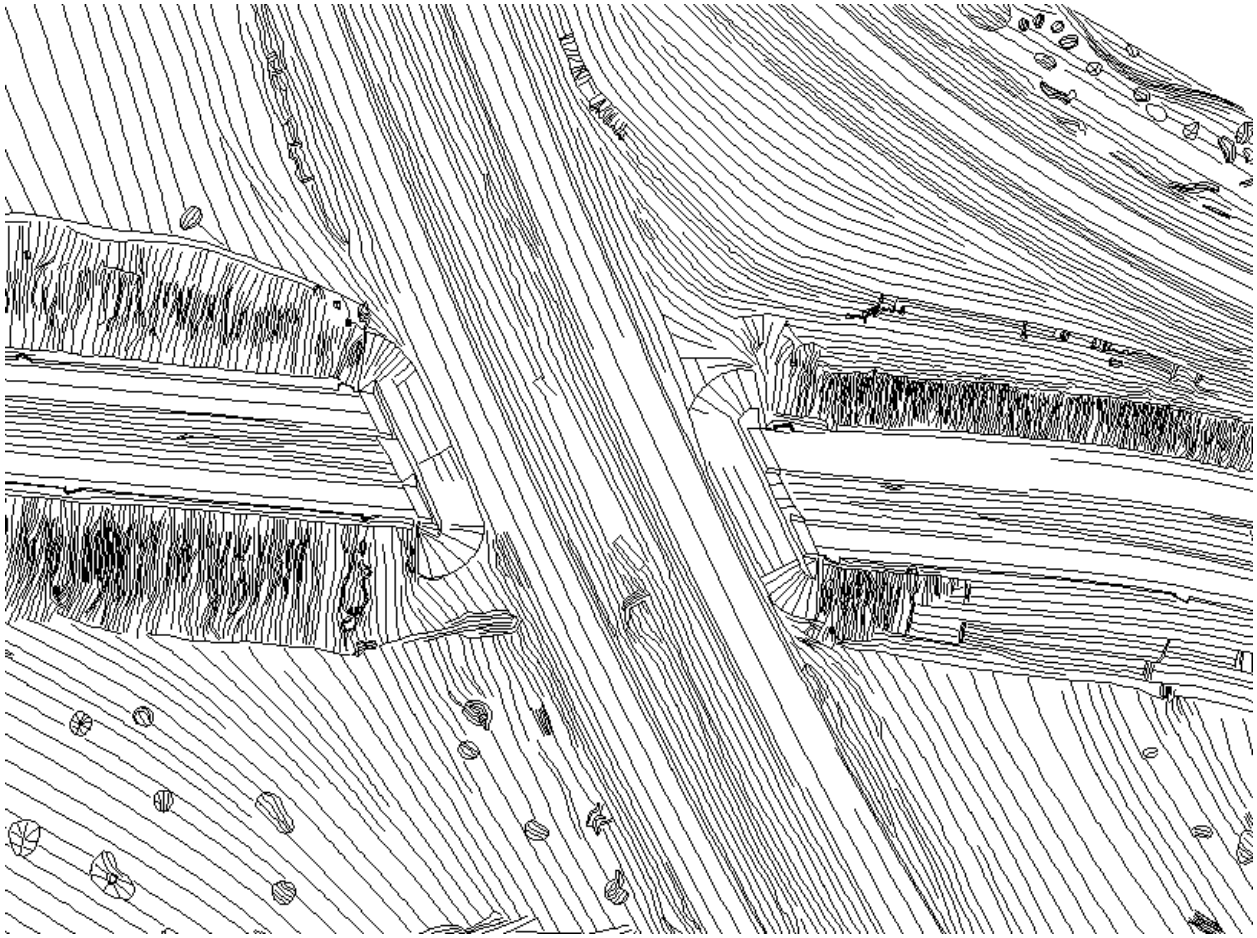


Figure 2 – DTM Breakline File Data

Appendix B
Sample Mapping Data

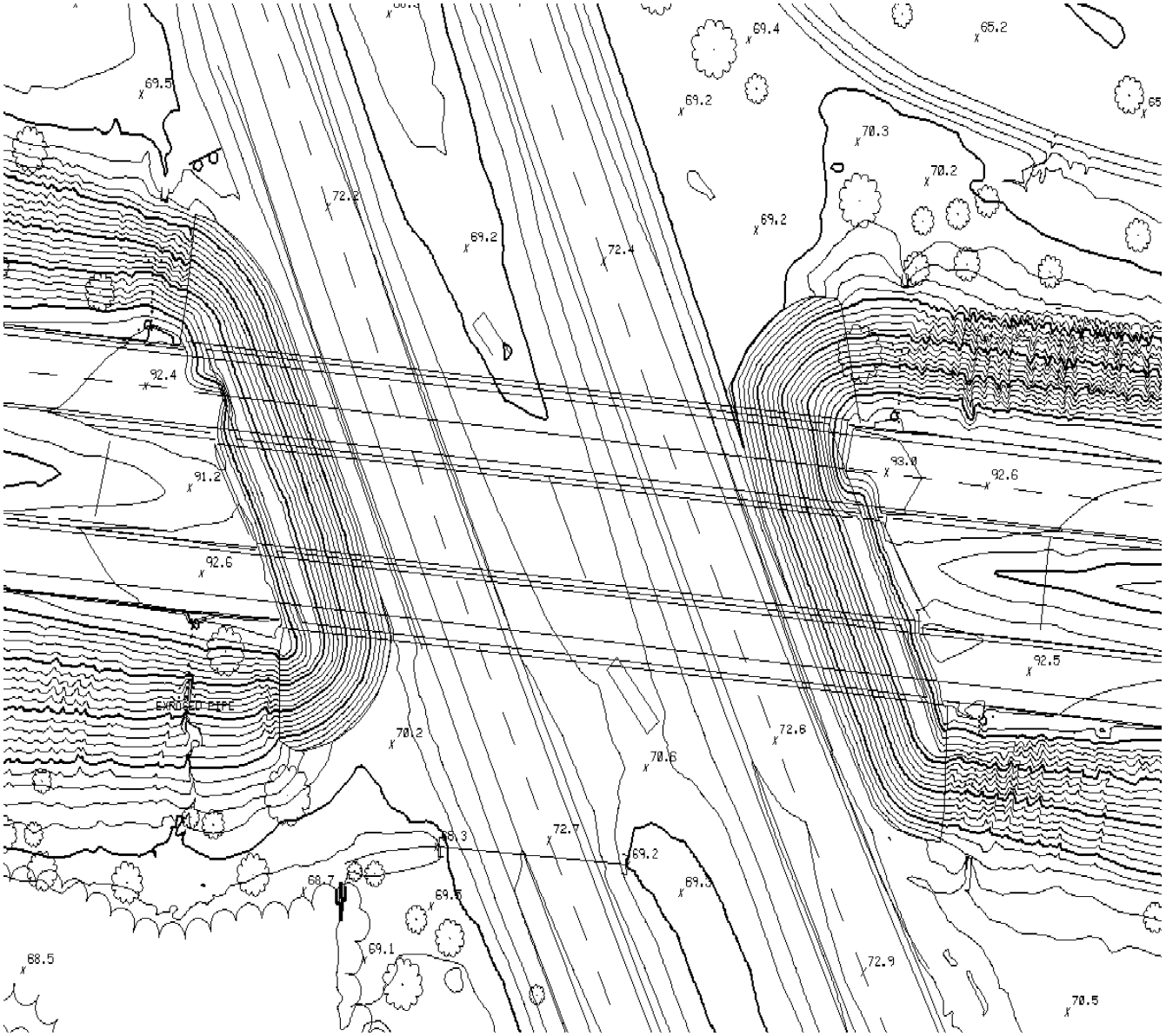


Figure 3 – Plan and Contour File Data Merged

Appendix B
Sample Mapping Data

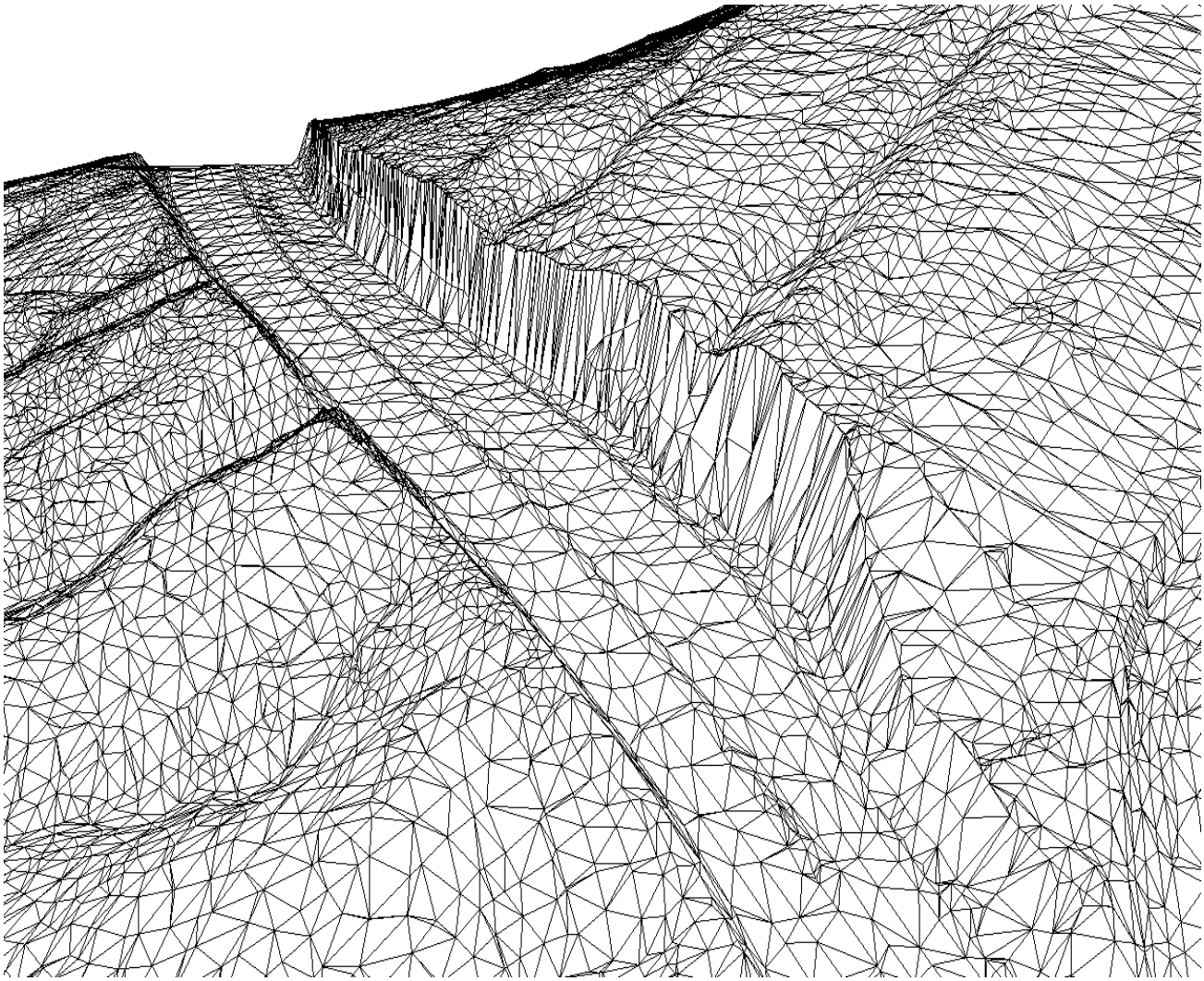


Figure 4 – TIN Data Showing Roadway